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ABSTRACT

As meta-analytic studies have become essential in educational research, resampling methods have matured and are supported by an in-depth theoretical and applied literature base. The objective of this paper is to assist researchers in applying resampling methods to the results of meta-analysis. The rationale for resampling methods is reviewed, and resampling applications and computational options are discussed. Three Statistical Analysis System macro programs for resampling meta-analyses are presented. To explore the potential of resampling, the paper proposes a research agenda. (Contains 11 references.) (SLD)

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Using Resampling Methods to Improve the Results of Meta-Analysis

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Abstract

Today, educational researchers must engage decades of primary research that is often interdisciplinary and from fields that continue to subspecialize. Consequently, meta-analytic studies are essential for cumulating findings and revealing new research opportunities. Indeed, as of June 30, 2001, the ERIC (Educational Research Information Center) database contained 1,516 documents matching the keyword meta-analysis. Congruently, resampling methods have matured and are supported by an in-depth theoretical and applied literature base. Herein, the objective is to assist researchers with applying resampling methods to the results of meta-analysis. Accordingly, the discussion proceeds along three lines. First, the rationale for resampling meta-analyses is reviewed. Second, resampling applications and computational options are discussed. (Note that three SAS macro programs for resampling meta-analyses are presented.) Finally, to further explore the potential of resampling meta-analyses, a research agenda is proposed.

Using Resampling Methods to Improve the Results of Meta-Analysis

In their watershed article, Adams, Gurevitch, and Rosenberg (1997) rhetorically ask "is . . . [the resampling of meta-analysis] really necessary " (p. 1281). Indeed, such a question seems somewhat trite until one considers the computational intensity required of most resampling methods (e.g., bootstrapping [i.e., taking a random sample of n items with replacement from a group of size n repeated k times] and randomization tests). Accordingly, the decision to resample should involve an assessment of distributional assumptions that underlie a given meta-analysis (Adams, Gurevitch, & Rosenberg, 1997). If one senses that the assumptions are not being meet, then nonparametric resampling may yield more power than either parametric or nonparametric ranking approaches (Adams, Gurevitch, & Rosenberg, 1997). Indeed, for those with a penchant for analysis, using all applicable approaches would seem most reasonable.

Resampling Applications

Within the context of treatment effect meta-analysis, three resampling applications have been advanced. These are (a) testing for heterogeneity of effect size variance, (b) computing effect size confidence limits, and (c) testing for moderator variables. A discussion of each application now follows:

Testing Variance Heterogeneity

According to Wang and Bushman (1999), "effect-size estimates should not be combined unless they are homogeneous or similar in magnitude" (p. 19). Consequently, formal test for assessing homogeneity in meta-analyses have been developed (e.g., the Q statistic for within and between studies variation; Wang and Bushman, 1999). With regard to resampling, between-studies variation is of interest. The results from an initial application by Adams, Gurevitch, and Rosenberg (1997) indicates general agreement between resampling and parametric approaches.

A detailed explanation of the randomization procedure is provided by Adams, Gurevitch, and Rosenberg (1997, p. 1279).

Computing Confidence Limits

An essential aspect of meta-analysis involves the computation of effect size confidence limits (intervals). Accordingly, Adams, Gurevitch, and Rosenberg (1997, p. 1279) computed confidence limits using both percentile and bias corrected percentile methods. In general resampling confidence limits tended to be wider than parametric limits. In the following statement Adams, Gurevitch, and Rosenberg (1997) describe an interesting outcome:

> In one instance, primary producers, the effect size was considered to be different from zero using standard confidence limits, but not different from zero using bootstrap confidence limits, implying that, in some instances, confidence limits derived from standard methods may be less conservative in establishing the significance of small to moderate effects. (p. 1280)

A detailed explanation of the bootstrap procedure is provided by Adams, Gurevitch, and Rosenberg (1997, p. 1279).

Testing Moderator Variables

In general, moderator variables interfere with the relationship between dependent and independent variables thereby causing a change in strength and/or direction (Baron & Kenny, 1986, as cited in Wang & Bushman, 1999). In meta-analysis, "moderators are any known study characteristics [e.g., date of publication, type of research design] that are associated with differences in effect-size estimates between studies" (Wang & Bushman, 1999, p. 14). Although much debated has transpired regarding the best approach for assessing moderator effects in meta-analysis (see e.g., Hall & Rosenthal, 1991; Viswesvaran & Sanchez, 1998), a consensus has not

been reached (Brown, Homer, & Inman, 1998).

According to Brown, Homer, and Inman (1998) the bootstrap multivariate regression offers several advantages over existing approaches for moderator analysis (e.g., independent t-tests). These are (a) increased detection of statistically significant moderator effects and (b) simultaneous analysis of study characteristics as opposed to sequential (Brown, Homer, and Inman, 1998). A detailed explanation of the bootstrap procedure is provided by Brown, Homer, and Inman (1998, p. 120).

Computational Options

Most general purpose computing packages can perform meta-analyses (see Wang & Bushman, 1999, for examples using SAS). Moreover, many packages have been designed specifically for meta-analysis (see Normand, 1995, for a review). Based on the author's collective review, only 1 package (i.e., MetaWin 1.0 and 2.0) supports the resampling of meta-analyses (see Rosenberg, Adams, & Gurevitch, 2000b, p. 46). It would be desirable to have a second option if for not other reason than to check one's MetaWin output. Accordingly, three SAS macro programs have been developed by the author to perform the resampling analyses discussed herein (SAS Institute, 1990). These are (a) %QB_STAR, (b) %CI_STAR, and (c) %MA_STAR. It should be noted that the above programs require four SAS utility macros (a) %SEEDS, (b) %LEVELS, (c) %WITHIN, and (d) %RANDOM. With the exception of %WITHIN (Wang & Bushman, 1999, pp. 266-267), all programs will be made available upon request (see Author Note for contact information).

Research Agenda

To improve the resampling of meta-analyses the following research agenda is proposed:

1. Explore the possibilities of using resampling with other meta-analytic methods. For example (a) validity generalization, (b) reliability generalization, (c) factor structure generalization, (d) the synthesis of simulation results, and (e) multivariate effect sizes. (Note that the later is of current interest to the author.)
2. Incorporate (or develop) resampling diagnostics for use with meta-analytic results. For example, (a) the iterative (or nested) bootstrap, and (b) the jackknife after bootstrap plot.
3. Explore the use of sensitivity analysis in conjunction with the resampling of meta-analytic results.
4. Assess the merits of existing meta-analysis programs for resampling. Questions of interests are (a) Which resampling features are common (or unique) among programs? (b) Which programs are easy (or difficult) to use? and (c) What discrepancies (if any) exist among program outputs?

Conclusions

Today, educational researchers must engage decades of primary research that is often interdisciplinary and from fields that continue to subspecialize. Consequently, meta-analytic studies are essential for cumulating findings and revealing new research opportunities. Resampling methods can improve these efforts.

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Author Note

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Based on the feedback from the reviewers of this paper, I am planning to develop a training session for the 2002 MSERA conference.

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